INDEPENDENT JOURNAL OF MANAGEMENT & PRODUCTION (IJM&P)
http://www.ijmp.jor.br v. 13, n. 5, May - July 2022
ISSN: 2236-269X
DOI: 10.14807/ijmp.v13i5.1766

SPATIAL LOCALIZATION CHARACTERISTICS IMPACT RESEARCH AT VALUE DETERMINING OF REAL ESTATE OBJECTS SITUATED IN SMALL SETTLEMENTS

Yuri Pozdnyakov
Ukrainian Appraisers ?ssociation Member, Ukraine
E-mail: jerzy.pozdniakow@gmail.com

Skybinska Zoryana
Lviv Polytechnic National University, Ukraine
E-mail: szm@ukr.net

Gryniv Tetiana
Lviv Polytechnic National University, Ukraine
E-mail: gtans@ukr.net

Submission: 8/11/2021
Revision: 12/1/2021
Accept: 12/9/2021

ABSTRACT

The article behaves to the property economic measurements implementation using the Comparative Sales independent expert valuation approach. On example from the real commercial real estate evaluation practice the main methodological principles of valuation object spatial localization characteristics adjustment are considered. According to the described methodology, localization adjustment coefficient is determined by calculation method on the basis of market data cross-correlation regressive analysis. A basic hypothesis is a statement that the relation of valuation object single unit value index to the same of comparable object is determined by its model values relation in the mathematical model of statistical relationship between object single unit value index and its three settlements characteristics: population number; distance to the regional center; area (territory within the settlement boundaries).

The research is grounded on mathematical simulation and mathematical statistic quantitative methods. The methodology of adjustment coefficients on investigated price-forming factors definition is based on nonlinear cross-correlation regressive analysis of market data research. This mathematical model is experimentally set by local market data research for the exactly similar real estate objects on the valuation date. It is set that there is observed different statistical relationship level between some of objects price-forming factors and its single square value indexes. The closest statistical relationship exists between settlements

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population number and single indicator of similar property situated in other compared settlements.

It is shown that taking into account some recommended braking coefficients for regressive curve, are published in professional literature, is inadvisable, because it increases the result error is got. Certainly the regression curve characteristics of object spatial localization price-forming factors must be taken into account at adjustment coefficient determination procedure. It is well-proven that methodically correct result of object localization adjustment procedure implementation can be provided only in the case of local market situation research data applying, with determination of the nonlinear regression function characteristics for statistical dependence of single square value index from the object settlements population number.

Research is described gives an opportunity to decrease evaluation result uncertainty through the use of new offered approach to mathematical model characteristics definition. The main result of researches described is a possibility to obtain appraising/valuation results with the higher reliability and better accuracy. Researches results are the objective confirmation of the fact, that nowadays methodical base of independent valuation is not able to provide the higher level of this class evaluation objects accuracy results. It does not depend only from an individual appraiser or concrete evaluation company, but, firstly, from unreliable arbitrarily chosen by appraisers adjustments - that usually are "expertly" determined, based on appraiser's own ideas about the dependence of real estate prices on the settlements characteristics. This elementary way of taking these characteristics into account may be a source of result additional errors and its uncertainty level increasing.

Future investigations in this direction may deals with the consideration and analysis of other types nonlinear functions application possibilities, that is approximate the regression curve of statistical interdependence between the object single value index and its spatial localization characteristics. The quantitative indexes of absolute and relative methodological errors also may be determined and analyzed in detail in future researches. The importance of those researches for the further development of the independent valuation metrological-information paradigm are confirmed. Practical recommendations for the evaluation results accuracy and reliability increasing are formulated.

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Keywords: *real estate independent valuation/appraising; Comparative Sales approach; valuation object; localization characteristics adjustment; mathematical simulation; linear and nonlinear cross-correlation regressive analysis methods; valuation result uncertainty*

1. INTRODUCTION

Real estate objects valuation/appraising situated in small settlements, performed by comparative sales approach, often causes difficulties, primarily due to the lack of similar property objects within the same village or town. The limited local property market of the same class property, to which the valuation object belongs, necessitates the analogues search in other similar settlements in the nearest neighborhood and in the region.

But in this case, the found analogues are differ in the characteristics of objects location, and this fact should be taken into account when adjustment evaluation procedure is performing. Adjustment arbitrary determining by an expert, based on the appraiser's own subjective views, is a source of evaluation result uncertainty growth. Fortunately, the adjustment correction for the object location can be objectively determined by calculation.

Below is described the object-oriented approach to such corrections determining, the advantage of which is the ability to objective consideration performance of the objects location characteristics. This avoids the influence of the appraiser's subjectivity in real estate value determining.

Research of the theoretical and practical aspects of higher formulated scientific problem has a great practical importance, because adjustment correction size have direct influence on economic measurements results uncertainty degree and its errors estimations. Research results, are verified on the concrete examples of real estate objects evaluation, will give an opportunity of mathematically strictly ground adjustment correction size, in order to improve evaluation results accuracy and reliability.

Mathematical model is considered in the study relates exclusively to the method of the correction factor calculating in adjustment procedure implementation by Comparative Sales approach. It is based on a market regularity study of the property, similar to the evaluation object, performed directly on the valuation date.

2. LITERATURE REVIEW

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The location of valuation objects, situated in the settlements of the region, significantly affects their value (Gribovsky & Sivets, 2008), that requires adjustment performing. Most of the authors are based on location adjustments determination size for real estate and land plots, depending on the distance from the reference center. As the basic reference centers usually are used: city centers, in studies of the objects location influence in cities; bypass road around the city, in studies of the objects location influence in regions (Jaskevych & Jaskevych, 2013).

In fact, this enables possible taking into account hedonic and prestige factors, that defined real estate demand level for a particular settlement. Other price-forming factors are: assessment of objects remoteness from region center and other centers of attraction; population size; the general assessment of the real estate market price characteristics in the city. As well as taking into account a number of non-obvious location characteristics, such as engineering and social infrastructure condition, ecological situation and others that have a significant impact on the real estate market value level (Baramzin, 2020).

The location adjustment reflects the change in real estate prices depending on the location of the object. To calculate this adjustment, few methods are used: paired sales; using analytical agencies data; method of ranking factors, based on analytical market research; and the method of cadastral values ratio. The use of one or another method is justified by the appraiser in each particular case, depending on the characteristics of the valuation object characteristics and market segment.

The method using analytical agencies data implies a comparison of the similar objects price in the real estate market, depending on the location. The method is implemented by the formula in which the percentage adjustment is defined as the ratio of the average 1 sq. m values of a similar objects in the valuation object location and the object-analog location, respectively, minus one (Vol'nova, 2015).

Statistical methods are usually considered in the context of the correlation and regression analysis application. In valuation practice, usually it is not possible to obtain a universal regression equation that takes into account all price-forming factors. While influencing factors number grows, the probability of multicollinearity manifestation is increasing - due to a relationship between two or more variables. As a result, some of the regression coefficients are no longer statistically significant.

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So, sometimes the correlation dependence is rather formal and devoid of economic sense. Location adjustment takes into account the remoteness of the selected analogs location from center, location prestigious estimation, transport accessibility, entrance convenience, etc. The location adjustment may be calculated as the ratio of the average values within each of the selected objects distance ranges (Kovalyova & Dvoryadkin, 2015).

Location characteristic of the valuation object is the most common, as well as one of the most significant price-forming factors for real estate and land plots value determining in the conditions of market relations economy. The need in location adjustments to correct the assessed value, when the location of valuation object differs from similar comparable objects.

For example, if an apartment is located far from a metro station or other public transport stop, then this directly effects on its market value downward. And vice versa, the apartment location proximity to the stops of trams, trolleybuses, buses and metro stations increases the price of an apartment. In the cities location adjustment may be up to 15% if the apartment is removed from the public transport stop, because valuation object location characteristic reduces its price. Moreover, every 200 meters from the public transport station to the apartment, namely every two minutes that the owner need to walk to get to the house, also affect its price downward by 1% for every 200 meters (Perlin, 2012).

One of the possible solutions of this problem may be a method of hedonic regression, to build a property price index estimation based on the analyzed market data (Taylor, 2008; Redfearn, 2009; Brasington & Hite, 2005; Li & Saphores, 2012). The essence of the hedonic method is assumed that the price of heterogeneous goods can be described using its price-forming features.

This method can be used to determine the price estimation based on individual characteristics of the valuation object. In order to determine the influence of individual features on the object value, econometric model equations are built, where the variables determine the value estimation. The hedonic method has many applications in the real estate appraising, but the most important seems to use it to determinate property market value indexes (Trojanek, 2013; Kim et al., 2016).

The issue of multivariate correlation hedonic modeling for residential real estate has been studied in detail in a large number of works, in particular (Beron et al., 2004; Mcmillen, 2010; Sirmans, 2005). Some of these works are devoted to the issues of taking into account the

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location characteristics (Small & Steimetz, 2012; Tsutsumi & Seya, 2009; Krause & Bitter, 2012; Koschinsky, Lozano-Gracia & Piras, 2012).

Hedonic methods, based on multivariate correlation, generally are very time consuming for mass asset valuations of small objects, such as apartments, flats, private houses, private land plots. The amount for ordinary multivariate correlation research work significantly exceeds the time which appraiser spent on all other elements of evaluation work. In addition, methods based on multivariate correlation are too complicated for the vast majority of average appraisers.

Methods based on multivariate correlation consider the whole set of price-forming factors and gives a generalized result of their impact on the evaluation object value. Then it is difficult to analyze the single one of all price-forming factors totality, and reveal in detail the nature and its impact degree independently of others.

The national regulatory framework for valuation in Ukraine requires that appraiser must to analyze every individual pricing factor and to determine adjustments for each of them. Therefore, the application of methods based on multivariate correlation is not allowed and not prohibited by current national evaluation standards. These methods can be used in addition as a way to verify the obtained evaluation result. However, adjustments for each of price-forming factors still should be identified.

In the future, fuzzy logic and machine learning methods can be used to create software for evaluation work productivity increase. This requires to make changes in existing evaluation standards and a sharp increase of appraisers average qualification level. Fuzzy logic and machine learning techniques are effective in scientific research, and are possible to apply also in the field of independent evaluation – but now this requires the participation of scientists and highly qualified specialists in mathematics, machine learning and artificial intelligence.

Ordinary appraisers have no access to this methodological framework and have no formal legal rights to use it. They are strictly limited by the requirements of the evaluation current regulatory framework. Neither national valuation standards in Ukraine nor International Valuation Standards provide the use of such methods in current valuation practice. Even if the qualification level of one of the evaluators allows him to use methods based on multivariate correlation, fuzzy logic and machine learning, this will be considered by state control bodies

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as a violation of the evaluation regulatory framework rules. Such an outstanding appraisal work is likely to be declared invalid and inofficious.

Analyzing regression dependencies should be taken into account that the sales proposals prices and even notarial transaction prices may be "real" prices, i.e. those for which real estate has actually been purchased, or "false". Real prices can be divided into true market prices and so-called "Amateur" prices. Amateur prices are the factual amounts that have been paid for real estate, but the terms of the transaction could have a subjective component both on the seller and the buyer side of the agreement (Hopfer, 2005).

False prices on sales offer sites may be caused by non-disposable mistakes of sellers, and also specially purposefully formed inadequate prices, in order to cause influence on the proposal market characteristics. False prices given in notarial acts are formed primarily due to the willingness to reduce the calculating fees and taxes basis for related to real estate transaction prices.

In addition, the information contained in notarial files relating to physical and qualitative features, often is limited, uncertain, insufficient to use in real estate valuation procedure (Dydenko, 2012). In our previous works it was considered valuation object characteristics influence on evaluation result uncertainty (Pozdnyakov, 2021; Pozdnyakov & Lapishko, 2021).

But until today there is no transparent method of taking into account object spatial localization characteristics at evaluation procedure performing by Comparative Sales approach. This still is one of the main components of evaluation result uncertainty source (Anselin & Lozano-Gracia, 2007; Anselin, 1988; Kelejian & Prucha, 2006).

3. RESEARCH METHODOLOGY AND THEORETICAL BACKGROUND

The general methodological base of the article is scientific and special for the subject sphere knowledge methods of scientific cognition, typical for econometrical researches. The research is grounded on mathematical simulation and mathematical statistic quantitative methods. The choice of methodological approaches is conditioned by the specific of the economic measurements, which are executed by independent expert appraising/valuation methods.

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The research is grounded on mathematical simulation and mathematical statistic quantitative methods. Research methodology also envisages generalization of previous publications results from scientifically-research sources and open sources statistic information.

Basic principles of independent expert appraising/valuation also made the general methodological basis of the article, in particular - principles of Utility, Substitution and The Highest and The Best Use. To the certain methods of research belongs the method of one-factor nonlinear cross-correlation analysis.

Determining the value of real estate objects in small settlements by Comparative Sales approach, domestic appraisers usually use publicly available sales proposals - because the market is not transparent, and completed transactions prices in Ukraine are not available to the average appraiser. These sales proposals do not reflect quite relevant the current state of the actual transactions market, but only gives an general idea of the near future state of the market.

They are adequately reflecting the real estate objects proposal level, but do not give a complete picture of demand. This applies to a range of Comparative Sales approach adjustments, in particular - to the settlement characteristics adjustment corrections. Using proposals data in a Comparative Sales approach, it should be borne in mind that majority of real estate sellers most often have not any idea of the market prices dependencies objective patterns, especially - related to settlement characteristics.

Sellers' expectations in small settlements are often based on available data obtained from media sources. Since there is no data of similar property sale offers within the same village, settlement or town, due to limited local real estate market, sellers usually focus their attention on sale offers public data, are available in the district center or in the nearest larger city. This means that the value characteristics of the locality, where the valuation object is located, usually are not taken into account in the sales proposals.

This fact makes it difficult to estimate correctly the value of real estate object in small settlements using a Comparative Sales approach. The average appraiser, faced with a lack of data on offers to sell same class property in the small town, where the appraised property is located, often either uses available data from other settlements.

At the same time, as a rule, he has a problem to make correct adjustments to the settlements characteristics. In this case appraisers often apply quite arbitrarily chosen adjustments, based on appraiser's own ideas about the dependence of real estate prices on the

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settlements characteristics. But, fortunately, the valuation methodological tools allow to take into account the peculiarities of spatial localization, at determining the value of real estate in small settlements.

These are, first of all, methods of nonlinear correlation-regression analysis, which make it possible to objectively determine the real estate value dependence on the quantitative characteristics of settlements. The object location adjustment can be calculated as the ratio of the settlements quantitative characteristics of the compared real estate objects, raised to the exponent, expressed by a number less than one - called the braking coefficient. But this interrelationship may be expressed with varying degrees of correlation tightness indicator.

Justification for this adjustment introducing occurs only in cases, where the market data clearly shows a pattern that reflects the steady trend of object value dependence on settlements quantitative characteristics changing. Statistical research on that dependencies with each price-forming factor can be carried out on the basis of the sales proposals prices data found at the market analysis. To quantify the spatial location correction adjustment for the evaluation object, is applied the condition of conformity of the evaluation object unit value indicator dependence on settlements quantitative characteristics mathematical model (Williams, 2004).

It is necessary to define mathematically strictly the indexes of appraised assets settlements quantitative characteristics. Let's consider the mathematical basis of proposed object-oriented technique. First of all, it is necessary to determine the list of settlements features quantitative characteristics that can be used as price-forming factors in a mathematical model.

The main requirement for them is, firstly, measurability (which implies their quantitative nature) and, secondly, accessibility (which implies easy availability of these data for any settlement). The analysis showed that these requirements are met by only three settlements characteristics: population number; distance to the regional center by highways and any automobile roads; area (territory within the settlement boundaries).

For most settlements in Ukraine, all three characteristics can be easily found in Wikipedia. If the distance to the regional center by road is not specified in Wikipedia, it is easy to set it using Google Maps. Also, the above characteristics can always be clarified on the websites of local communities or administrations. Characteristics of settlements "population" and "area" correspond to adjustment on the price-forming factor "Size of the settlement"; the

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characteristic "distance to the regional center" corresponds to the adjustment on the price-forming factor "Location within the region".

For each of the mentioned above three parameters using nonlinear correlation analysis, a regression model can be built, that reflects the statistical relationship between this parameter and the value of a single indicator of similar property in other compared settlements. By this way, quantitative indicators can be obtained, that characterize the statistical relationship density between the investigated characteristics.

If there is noted a sufficiently significant statistical relationship, the characteristics of the three regression curves can be obtained and used, which exhaustively quantify the nature of these relationships. According to these models, it becomes possible to determine the model values of a single indicator for the evaluation object and comparison object, depending on the settlements quantitative characteristics for each of them. Practice has shown that as a function that approximates the regression curve, it is most appropriate to use the power function - similar to what is done when calculating the scale adjustment (Pozdnjakov & Lapishko, 2019; Pozdnyakov & Sadovenko, 2020a; Pozdnyakov & Sadovenko, 2020b).

Similarly, adjustments can be made for a certain number of other parameters. Then the model single unit indicator value v of the *i*-th parameter will be determined by the power function

$$v = a\ P_i^b \quad (1)$$

where *a, b* - are the characteristics of the power function,

P_i - is the numerical value of the *i*-th parameter, for example - mentioned above three settlement features quantitative characteristic.

Accordingly, the model single unit indicator values of the evaluation object v_{vo} and the comparison object v_{co} on the *i*-th parameter will be determined by the expressions

$$v_{vo} = a\ (P_{i\,vo})^b \quad (2)$$

and

$$v_{co} = a\ (P_{i\,co})^b \quad (3)$$

where v_{vo} - is the model single unit indicator value of the valuation object,

v_{co} - is the model single unit indicator value of the comparison object.

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Therefore, with the known characteristics *a, b* of the mathematical model is defined, which determines the dependence of single unit indicator value on the selected *i*-th parameter P_i, the numerical value of the correction factor K_i to make adjustment for this *i*-th parameter can be calculated by

$$K_i = \frac{v_{vo}}{v_{co}}. \qquad (4)$$

Substituting in (4) the right parts of equations (2), (3) and making the obvious reduction we obtain the expression for the correction factor K_i :

$$K_i = \frac{{P_{i\,vo}}^b}{{P_{i\,co}}^b}. \qquad (5)$$

Obtained above formula (5) proves that the values of this coefficient depend only on the characteristic *b* of the mathematical model power function. Equation (5) can easily be simplified to a more compact expression

$$K_i = \left(\frac{P_{i\,vo}}{P_{i\,co}}\right)^b, \qquad (6)$$

where $P_{i\,vo}$, $P_{i\,co}$ - are the numerical values of the *i*-th parameter for the valuation object and the comparison object, respectively.

The above equation (6) is a mathematical proof that the value of the correction factor K_i , use to perform the *i*-th parameter P_i adjustment, does not depend on the characteristic *a* of the regression curve of type (1) power function, and it is determined only by its characteristic *b*. This equation (6) is the most convenient for application in evaluation practice, because it allows to reliably determine the size of the correction factor K_i for an arbitrarily selected *i*-th parameter P_i in all cases, when the valuation object and the comparison object characteristics are differ on this parameter.

The application of the one-factor nonlinear correlation-regression analysis method in such cases is expedient, since the values of the correction factor K_i are determined on the basis of the real dependence of similar to the evaluation object property price characteristics on the selected price-forming factor parameter.

In this case, the model single unit indicator values of the valuation object v_{vo} and the comparison object v_{co} for this *i*-th parameter are determined on the basis of a recent made study of the local real estate market current condition, performed by appraiser directly on the valuation date. Practice has shown that the variability of the mathematical model characteristics

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a, b is quite high - depending on the selected price-forming factor parameter, objects spatial localization and temporal dynamics of change.

Therefore, great care should be taken when using the results of any research obtained at other times and in other regions. It is not possible to recommend the practical application of such results obtained from sources of professional literature, if it is no possible to verify them locally on the valuation date. The use of any generalized values unverified data of correction factors, are recommended in the professional literature and periodicals, should be considered completely inexpedient.

They are relevant only for a specific property class objects, specific region and a specific date, and may be completely inadequate for another class objects, another region and another valuation date. Any unverified information may be completely useless, and then appraiser is forced to make some arbitrary assumptions about the correction factor quantitative estimation, based only on his own subjective ideas and beliefs.

In each case, a full study of the statistical relationship density for the same class property local market on a specific valuation date should be performed, and only in the case of sufficient statistical significance level achievement the required degree of valuation result uncertainty will be met.

4. CONDUCTING RESEARCH AND RESULTS

Let us illustrate the above theoretical considerations with a concrete example from evaluation practice. Further the real data of commercial real estate market research of the Lviv region southern areas are used. The appraisal task is to determine the market value of commercial retail object - the store with a total area of 114 sq. m in the town Stebnyk.

There are no any offers to sell such kind of property within the town, except one sale proposal. The initial data for the study were sale proposals of commercial real estate objects, obtained from open sources. It was used a sample of 45 offers for the retail space sale, obtained from the site: https://www.real-estate.lviv.ua on a date of April 12, 2021. This is the most complete and representative site for the sale of real estate objects in the region.

In accordance with the principles of the described above approach, in order to find adequate offers, it is advisable to search for objects of similar property in the settlements within the administrative district where the valuation object is located, and neighboring areas. For further analysis, it is advisable to consider a number of sales proposals, ranked by the single

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unit indicator value "Seller's offered price per unit area", as it gives a more complete picture of the variation range in comparable value indicator units. In the former representative sample, ranked on values of unit indicator, there is a significant variation of the indicator "Seller's offered price per unit area", in the range of 133 - 2 381 UAH / sq. m, including VAT.

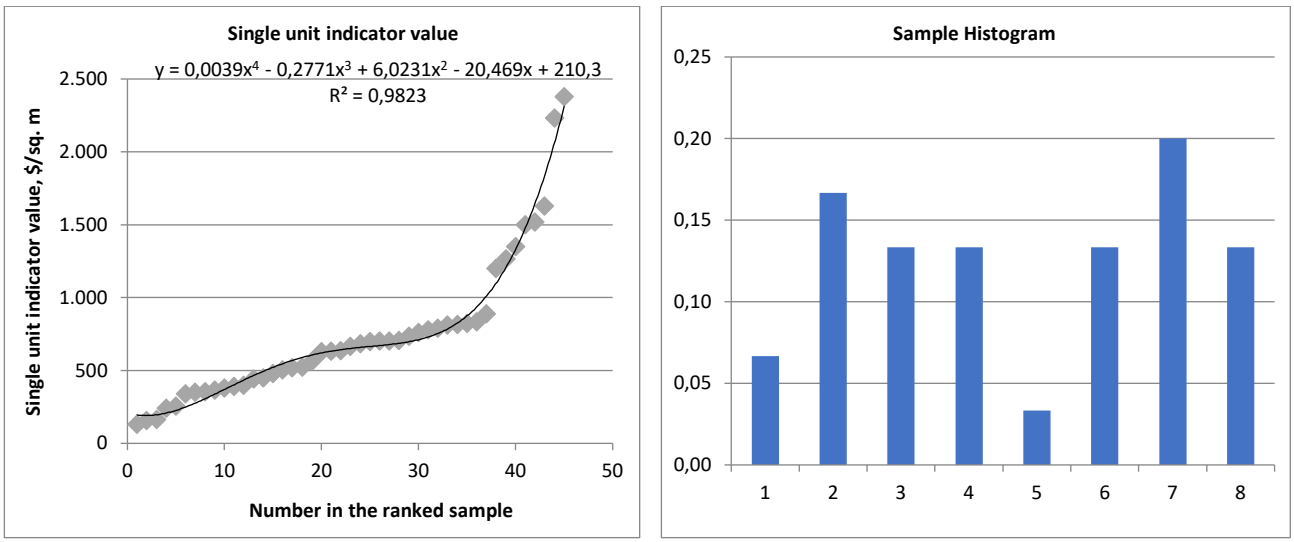

Figure 1: Graph of the sales offers single unit indicator value growth in the ranked initial proposals sample, approximation function formula and determination coefficient value (left).
Source: diagrams are developed by the authors.

Histogram of a sales offers single unit indicator value range, cleared of potential emissions (gross errors). On the x-axis - the histogram interval numbers; along the y-axis - the relative frequency of these intervals (right).

The above graph (Figure 1**,** left) is useful for the appraiser because of visual analysis possibility to determine the probability density distribution law of the studied parameter. Probable emissions are also immediately visible on the chart. Thus, it is possible to estimate the location of the histogram modal interval on the law of probability distribution, elementary comparing the number of observations included in each interval of the studied parameter.

Looking at this graph, we can conclude that the largest number of observations are located in the interval range of 341 - 833 UAH / sq. m, including VAT. Other values, that are not included in this interval, are obviously very different from this compact homogeneous set, which contains typical for the proposals market data array. So, that minimum and maximum non-typical values of the primary sample with a high probability can be identified as potential emissions.

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Qualitative analysis, performed as described above, allows to determine at a glance, in which part of the graph may be located the center of the probability density distribution law. Therefore, it is possible to determine, what is the approximate range of the most probable single unit indicator values for a given set of market data. But to formulate more detailed conclusions, these results of intuitive visual analysis must be confirmed by the results of quantitative analysis, with the distribution histogram creation.

The resulting histogram (Figure 1, right) is characterized by the "failure" presence in the interval №5 and rather distant similarity to the classical normal distribution - which, after all, is typical in the data study of small real estate markets. As can be seen from the above histogram, the sample is single-modal and it is characterized by the one modal interval presence, namely: the interval №7 with the limits of 669.18 - 740.39 UAH / sq. m, with VAT, with a frequency of 6 and a relative frequency of 0.20. Thus, it is mathematically proved that the probability density distribution center of the primary sample lies within this modal interval.

Next, the nature of the following statistical dependences for 3 mentioned above price-forming factors are defined.

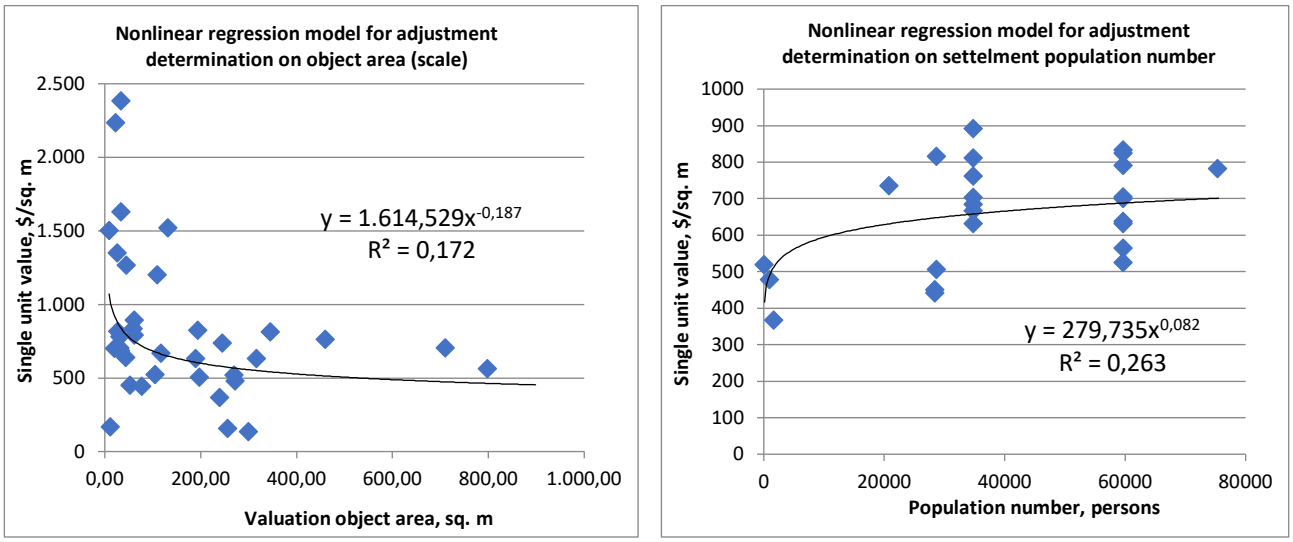

Figure 2: Graphical interpretation of the statistical relationship study results using nonlinear correlation-regression analysis. Correlation between the single unit value of sales offers and the valuation object area (left); and the settlement population number (right).
Source: diagrams are developed by the authors.

The graph is shown in Figure 2 (left) provides a basis for determining the size of the scale adjustment. Made above analysis of the market value formation mathematical principles gives grounds to assert that the single unit value indicator of the appraised object should be

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adjusted by a correction factor, determined by formula (6), in which indicator b is equal to the exponent of the regression curve power function is shown in Figure 2 (left).

The graph is shown in Figure 2 (right) shows the correlation between the single unit value and population number of people are living in the settlement. Obviously, the larger size settlements, measured by population number, demonstrate the higher single unit value indicators for commercial real estate objects. The theoretical basis for the such statistical dependence existence are the basic valuation principles, such as Dependency, Utility, Anticipation, Substitution and The Highest and The Best Use.

In particular, dependency basic principle states that the value of a particular property is affected, and itself affects, on the value of other properties located in the same region. To determine the impact on real estate value the territorial location the concept of Situs is used, which takes into account economic characteristics of the real estate object location (Friedman & Ordway, 1995).

As can be seen from Figure 2, the cloud of correlation field marks is characterized by a fairly large scattering of a sales offers single unit value indicators, and the obtained values of the correlation coefficient (correlation ratio). The determination coefficient $R^2 = 0.115$ (for dependence on the premises area) and $R^2 = 0.274$ (for dependence on population).

It indicate the presence of a sufficiently strong statistical relationship between these parameters. According to table 4.1 "Quantitative criteria for statistical relationship density estimating" (Syvets, 2001, p. 103), the obtained values of the correlation coefficient for the dependence on the area give grounds to characterize the degree of statistical density as "Moderate".

Depending on the population, the degree of statistical density is defined as "Notable". The obtained data convincingly indicate the presence of a sufficiently close statistical relationship between the studied parameters. The probabilistic nature of the interdependence of the studied parameters revealed by the research showed the absence of their functional connection and the presence of high enough correlation - which confirms the expediency of the approach to their analysis as random variables, which opens the possibility of using the information for scale and size of the settlement (by population) adjustments calculation.

In contrast to the above dependence of sales offers single unit value indicators on the settlement population, similar dependences on the settlement area and the distance from

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settlement to the regional center by road are characterized by a much lower statistical relationships density. In Figure 3 are shown the correlation fields marks clouds for these price-forming factors. The obtained values of the correlation coefficient (correlation ratio) and the determination coefficient of $R^2 = 0.024$ (depending on the distance from the settlement to the regional center) and $R^2 = 0.069$ (depending on the settlement area) indicate the absence of a strong statistical relationship between these parameters.

According to (Syvets, 2001, p. 103), the obtained values of the correlation coefficients give grounds in both cases to characterize the degree of statistical density as "Practically absent".

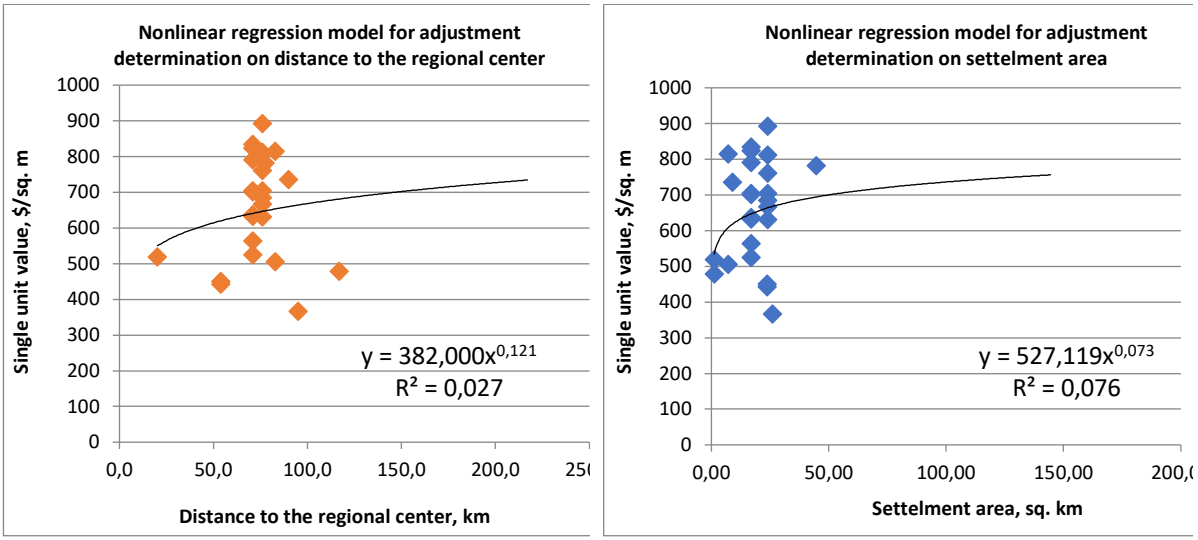

Figure 3: Graphical interpretation of the statistical relationship study results using nonlinear correlation-regression analysis. Correlation between the single unit value of sales offers and the distance from the settlement to the regional center (left); and the settlement area (right).
Source: diagrams are developed by the authors.

The obtained data indicate the absence of a close statistical relationship between the studied parameters - and hence, confirm the inexpediency of making adjustments to these price-forming factors. Moreover, with such a weak correlation, even the qualitative nature of the obtained dependences may be false: the regression curve in Figure 3 (left) indicates single indicator increase with distance from the settlement to the regional center increasing, which is rather contrary to common sense.

There are no sufficient grounds to speak about the existence of such a dependence at all, and it is more correct to state the fact of any dependence absence. The regression curve in Figure 3 (right) indicates single indicator increase with settlement area increment. In general, we can agree with this, because for larger settlements the comparable price characteristics of

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commercial real estate are usually higher - in accordance with the described above theoretical justification.

But in this case, only the fact of statistically significant dependence absence can be sufficiently proved, because the weakness of the statistical relationship between the studied parameters does not allow to use the obtained regression curve characteristics for corresponding correction adjustment calculation.

Undoubtedly, the settlement size should be taken into account, but, as the study showed, in this case it is better to use as a meter the population number, rather than the settlement territory area. Although the qualitative nature of the dependencies in both cases is the same - there is an single unit value indicators growing with an increase in the settlement size, which is true.

In this case, the exponent indicators of the regression curve power function, which determine the correction quantitative value, in both cases are quite close: b = 0.082 and b = 0.073. But it would be a methodological error to use the value of b = 0.073, obtained for the dependence of a settlement area at such small values of $R^2 = 0.069$; R = 0.263. Instead, there are sufficient grounds for the application of the indicator b = 0.082, obtained for the settlement population dependence at sufficiently large values of $R^2 = 0.274$; R = 0.524.

5. INTERPRETATION OF DATA RECEIVED AND DISCUSSION

It should be taken into account that both analyzed price-forming factors are different characteristics of the settlement size - so, they cannot be considered as independent parameters. They are obviously correlated with each other, which is easy to prove by their statistical relationship analyzing. For the primary list of settlements we obtained the value of the correlation coefficient (correlation ratio) $R = 0.809$ - which allows us to characterize the degree of statistical relationship density as "Strong", according to (Syvets, 2001, p. 103).

Therefore, it seems inexpedient to introduce both adjustments at the same time. In this case, in fact, will be given double consideration of the same characteristic, namely - the settlement size. This could only increase the evaluation work result uncertainty degree. Therefore, even if a market study shows a high statistical relationship for both of these price-forming factors, only one of them should be used. The best is to use that one for which higher value of the correlation coefficient (correlation ratio) will be obtained.

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According to the described method, for each of the primary objects sample were received 3 correction factors, according to formulas (4) - (6). The largest correction coefficients variation is observed for scale adjustment factors: corrections in percentage terms range from -37.8% to 43.9%.

These are the extreme points of the correction coefficients range - and they obviously do not belong to the objects sample that will be used in the evaluation procedure. Of course, when choosing the objects to be used in the evaluation, preference should be given to objects whose premises areas are closer to the valuation object area - rather than taking the objects with the largest difference, which formed shown above extremes of the correction factors range.

For a range of adjustment factors for the settlement size measured by population, there is a slightly smaller variation of the series: the percentage adjustment lie in the range from -10.0% to 51.6%. But again, these range limits correspond to the objects that are most differ from the valuation object - which should not be used as an analogues, preferring objects with closer characteristics.

Finally, the minimum variation is observed for a range of the distance to the regional center adjustment factors: the amount of corrections in percentage does not exceed 2% in absolute terms. This is due to the fact that, in accordance with the above recommendations, the adjustment used the minimum value of the braking factor b = -0.01, because for this price-forming factor the degree of statistical density is characterized as "Practically absent".

In this case, it was possible to abandon the application of the corrections at all, because there are no mathematically proven grounds for it. When the market study revealed the lack of sufficient statistical significance of the correlation coefficient, the minimum value of the braking factor should be applied, which had almost no effect on the evaluation work result. In this case, the distance to the regional center adjustment is quite formal, and the information about it in the report should only indicate that the appraiser performed research of this price-forming factor, and its impact on the result was defined as insignificant, according to the study.

Considering in a broader context the question of the corrections size validity in the adjustment procedure, it is necessary to formulate a basic conception for the adjustment procedure correctness for price-forming factors of object location (spatial localization). From our point of view, it should look like this: the correction should be in strict accordance with the dependence pattern that is objectively observed in the local market of property, similar to the

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valuation object on the valuation date. So, in order to perform correctly location characteristics adjustment, appraiser needs to determine the type of pattern in which the value of a single indicator depends on the spatial location characteristics of such property.

Moreover, it is necessary to know this dependence type not in general form only - as a kind of approximating function (for example, linear, exponential, power). Otherwise, this dependence must be known in the form of a very specific and complete mathematical description, i.e. - as the equation of this function with numerical values of constant coefficients. And only on the basis of this specific dependence pattern adequate corrections can be calculated.

Unfortunately, this quite obvious condition for now has not been formulated in this form in any normative document or even in the professional literature. It seems to be implicitly assumed by default, but its implementation is not required by independent evaluation standards. Therefore, in evaluation practice, there are a lot of examples of this adjustment performing according to certain well-known and recommended models.

The use of dependency equations numerical indicators obtained on the basis of other markets studies, performed on other dates, sometimes - many years ago, is widely practiced. Appraisers often use such data without any verification of the used model correctness and its compliance with the current realities of a particular evaluation situation, which is completely unacceptable.

It should be emphasized that two very important conclusions follow from the formulated above postulate. Firstly, a full study of the local same property market necessary must be performed, due to determine an adequate correction. This study should be performed in a sufficient volume extent, to obtain statistically significant conclusions about the equation coefficients of approximate regression function.

Secondly, an objective assessment of single value indicator on the property spatial location dependence reliability must be obtained. Such a relationship never is functional, but always - statistical, and this means the need to quantify statistical density. That requires the values calculation of the determination coefficient, correlation coefficient or correlation ratio.

In fact, these indicators will fully determine the density of the correlation between the studied variables - and hence the statistical significance of the identified relationship pattern. The application of any price-forming factor adjustment will be sufficiently mathematically

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justified only in the case of sufficiently high correlation between the specified parameters. After all, it is quite possible that for a certain valuation situation, such a dependence is not clearly expressed, or there is no statistical connection at all - as we can see in the example above.

The practice of valuations performing and valuation reports reviewing gives us reason to conclude that for different types of assets, different local markets, different valuation dates, and sometimes even for different sample sizes and different types of approximation function, both values of its equations coefficients and correlation density parameters can vary significantly.

The scatter range of these parameters indicators is quite large, and it would be too risky to neglect it and to use some average values. Therefore, the adequate correction used in adjustment procedure will be calculate correctly, taking into account differences in the price-forming factor of appraised object spatial location, if: 1) correction strictly corresponds to the actual dependence of the single indicator value on the location characteristic of similar property; 2) this actual dependence in a particular valuation situation can be reliably established and is statistically significant. The verification of both of the mentioned above conditions can be carried out only if a careful study of the same property local market research is carried out, the results of which should be reflected in the valuation report.

The up-to-date national valuation regulatory framework of Ukraine does not require this from the appraiser and does not specify the correction method and correction index determining the valuation object location adjustment. It leaves him a lot of space to choose the calculation method and the validity degree of the correction size. National valuation standards do not specify the degree and completeness of market research; choice of correction calculating method; conditions of initial data sources use for this purpose.

Therefore, there are no legal formal grounds to require of the appraiser to carry out this work in full scope, when ordinary appraisal work is performing. However, the proposed approach can be effectively applied in evaluation procedure correctness verifying; in the process of valuation reports reviewing; or any subsequent verification of reports. The mathematically rigorous validity of the considered above approach makes its result indisputable evidence in trial litigation, in reviews conflict situations, in cases of bringing charges against the appraiser by state institutions, and so on.

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The described method makes it possible to objectively determine the correction size for the location price-forming factors of evaluation object and thus to minimize the uncertainty degree of the obtained evaluation result.

The application of one-factor regression analysis method is practically the simplest and easiest way to determine reliably the correction factor size for price-forming factors of spatial localization, in cases where the location of the evaluation object and the comparison object differs. This eliminates the need for making an arbitrary "expert" assumptions about the correction factor value, based only on the appraiser's own subjective beliefs.

After all, even an highly experienced specialist cannot guess the correct quantitative characteristics of the single indicator value on the location characteristics dependences by purely intuitive "expert" methods. Therefore, the values of corrections arbitrarily chosen by the appraiser, but not confirmed by quantitative market analysis, should be considered as unreasonable and insufficient evidence.

To substantiate the numerical values of these characteristics, the traditional method of linear or nonlinear regression analysis can be successfully used, which is used when it is necessary to identify the type of relationship of statistically related parameters.

6. CONCLUSIONS

The most important conclusion of the research is the proven to use in location characteristics adjustment corrections calculating of general analytical expressions are received in the article, that determine the impact of the pricing factor on the single unit value indicators of the evaluation object.

The parameters *a, b* of these type (1) equations should be determined on the basis of a same class property local market conditions study, which makes possible to obtain real characteristics of the statistical relationship between researching parameters. The regularity of single unit value indicators nonlinear change at change of location characteristics is confirmed; the influence of price-forming factors on the correction factors values is established.

It is found that the nonlinearity degree of this function, i.e. the slope of characteristic, depends on the value of the power function braking coefficient. An important practical recommendation is the mathematically proven expediency the results of market situation empirical studies on the evaluation date using, to determine the values of the braking coefficient for location characteristics adjusting.

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The possibility of determining this correction by calculation, according to the mathematically formalized algorithm described above, opens the possibility of eliminating the subjective error component and reducing the impact of economic measurements methodological error (Pozdnyakov et al., 2021).

The method described in the article was tested in the current evaluation works and showed the possibility of evaluation work results accuracy and reliability increasing. The approach described in the paper to perform the procedure of spatial localization characteristics adjustment can also be extended to other types of calculated adjustments on some other price-forming factors.

A promising area of further research development in this direction is the study of other types of nonlinear functions, which approximate the curve of statistical dependence between the single unit value indicators - in particular, polynomial and logarithmic functions of the regression curve. Indisputable interest also presents the study of the other price-forming factors influence on evaluation work result.

The use of research results in evaluation practice allows to reduce the degree of evaluation results uncertainty and increase the overall methodological support level, within the application of the information-metrological approach concept.

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